CLAIMS

What is claimed is:

1. A material processing system comprising:

a process tool;

a plurality of sensors coupled to said process tool to measure tool data; and

a controller coupled to said plurality of sensors and configured to receive said tool data, said controller configured to use a process performance prediction model to determine predicted process performance data from said tool data, to compare said predicted process performance data with target process performance data, and to use said comparison to detect a fault.

2. The material processing system as recited in claim 1, wherein said process performance data comprises at least one of mean etch depth and etch depth range.

3. The material processing system as recited in claim 1, wherein said tool data comprises at least one of a capacitor position, a forward radio frequency (RF) power, a reflected RF power, a voltage, a current, a phase, an impedance, a RF peak-to-peak voltage, a RF self-induced direct current bias, a chamber pressure, a gas flow rate, a temperature, a backside gas pressure, a backside gas flow rate, an electrostatic clamp voltage, an electrostatic clamp current, a focus ring thickness, RF hours, and focus ring RF hours.

4. The material processing system as recited in claim 1, wherein said process performance prediction model comprises an output from a partial least squares analysis.

5. The material processing system as recited in claim 1, wherein said fault occurs when a difference between said predicted process performance data and said target process performance data exceeds a threshold difference.

6. A process performance prediction system comprising:

a plurality of sensors capable of being coupled to a process tool to measure tool data; and

a controller coupled to said plurality of sensors configured to receive tool data, said controller configured to use a process performance prediction model to predict process performance data from said tool data, to compare said process performance data with target process performance data, and to use said comparison to detect a fault.

7. The process performance prediction system as recited in claim 6, wherein said process performance data comprises at least one of mean etch depth and etch depth range.

8. The process performance prediction system as recited in claim 6, wherein said plurality of sensors are capable of measuring said tool data that comprises at least one of a capacitor position, a forward radio frequency (RF) power, a reflected RF power, a voltage, a current, a phase, an impedance, a RF peak-to-peak voltage, a RF self-induced direct current bias, a chamber pressure, a gas flow rate, a temperature, a backside gas pressure, a backside gas flow rate, an electrostatic clamp voltage, an electrostatic clamp current, a focus ring thickness, RF hours, and focus ring RF hours.

9. The process performance prediction system as recited in claim 6, wherein said process performance prediction model comprises an output from a partial least squares analysis.

10. The process performance prediction system as recited in claim 6, wherein said fault occurs when a difference between said predicted process performance data and said target process performance data exceeds a threshold difference.

11. A process performance prediction system comprising:

a plurality of sensors capable of being coupled to a process tool to measure tool data;

means for predicting process performance data from said tool data; and

means for detecting a fault by comparing said process performance data with target process performance data.

12. A method for constructing a process performance prediction model for a material processing system, the method comprising the steps of:

recording tool data for a plurality of observations during a process in a process tool, said tool data comprises a plurality of tool data parameters;

recording process performance data for said plurality of observations during said process in said process tool, said process performance data comprises one or more process performance parameters;

performing a partial least squares analysis using said tool data and said process performance data; and

computing correlation data from said partial least squares analysis.

13. The method for constructing a process performance prediction model as recited in claim 12, wherein said step of recording tool data for a plurality of observations includes the step of forming a tool data matrix.

14. The method for constructing a process performance prediction model as recited in claim 12, wherein said step of recording process performance data for said plurality of observations includes the step of forming a process performance data matrix.

15. The method for constructing a process performance prediction model as recited in claim 12, wherein said correlation data comprises a correlation matrix.

16. The method for constructing a process performance prediction model as recited in claim 12, wherein said process performance data comprises at least one of mean etch depth and etch depth range.

17. The method for constructing a process performance prediction model as recited in claim 12, wherein said tool data comprises at least one of a capacitor position, a forward radio frequency (RF) power, a reflected RF power, a voltage, a current, a phase, an impedance, a RF peak-to-peak voltage, a RF self-induced direct current bias, a chamber pressure, a gas flow rate, a temperature, a backside gas pressure, a backside gas flow rate, an electrostatic clamp voltage, an electrostatic clamp current, a focus ring thickness, RF hours, and focus ring RF hours.

18. The method for constructing a process performance prediction model as recited in claim 12, wherein said step of performing a partial least squares analysis includes the step of determining a minimum number of partial least squares components that substantially explain a correlation between said tool data and said process performance data.

19. The method for constructing a process performance prediction model as recited in claim 12, wherein said step of performing a partial least squares analysis includes the steps of:

calculating variable importance in projection data defined as an influence on said process performance data of said tool data; and

refining said tool data based upon an analysis of the variable importance in projection data.

20. The method for constructing a process performance prediction model as recited in claim 12, wherein said step of performing a partial least squares analysis includes the step of verifying the fitting power of said process performance prediction model by inspecting at least one of a fraction of a sum of squares of all of said tool data and said process performance data explained by the partial least squares component, a fraction of a variance of all of said tool data and said process performance data explained by the partial least squares component, a cumulative sum of squares of all of said tool data and said process performance data explained by the partial least squares component, and a cumulative variance of all of said tool data and said process performance data explained by the partial least squares component.

21. The method for constructing a process performance prediction model as recited in claim 12, wherein said step of performing a partial least squares analysis includes the step of verifying the predictive power of said process performance prediction model by performing cross validation.

22. A method for predicting process performance of a material processing system using a process performance prediction model, the method comprising the steps of:

initiating a process in a process tool of said material processing system;

recording tool data for at least one observation during said process in said process tool to form a tool data matrix, said tool data comprises a plurality of tool data parameters;

performing a matrix multiplication of said tool data matrix and a correlation matrix to form a process performance data matrix, said correlation matrix comprises said process performance prediction model; and

predicting said process performance of said material processing system from said process performance data matrix.

23. A method for detecting a fault in a material processing system using a process performance prediction model, the method comprising the steps of:

initiating a process in a process tool of said material processing system;

recording tool data for at least one observation during said process in said process tool to form a tool data matrix, said tool data comprises a plurality of tool data parameters;

performing a matrix multiplication of said tool data matrix and a correlation matrix to form predicted process performance data, said correlation matrix comprising said process performance prediction model;

comparing said predicted process performance data with target process performance data; and

determining a fault condition of said material processing system from said comparing step.

24. The method for detecting a fault in a material processing system as recited in claim 23, wherein said step of comparing said predicted process performance data with target process performance data comprises determining difference data between said predicted process performance data and said target process performance data.

25. The method for detecting a fault in a material processing system as recited in claim 24, wherein said step of determining a fault condition of said material processing system comprises comparing said difference data with threshold difference data.

26. The method for detecting a fault in a material processing system as recited in claim 25, wherein a fault in said material processing system is detected when said difference data exceeds said threshold difference data.

27. A method for detecting a fault in a material processing system, the method comprising the steps of:

recording first tool data for a plurality of observations during a first process in a process tool to form a first tool data matrix, said first tool data comprises a plurality of tool data parameters;

recording first process performance data for said plurality of observations during said

first process in said process tool to form a first process performance data matrix, said first

process performance data comprises one or more process performance parameters;

performing a partial least squares analysis using said first tool data matrix and said

first process performance data matrix;

computing a correlation matrix from said partial least squares analysis, said

correlation matrix comprises a process performance prediction model;

performing a matrix multiplication of said first tool data matrix and said correlation

matrix to form target process performance data;

initiating a second process in said process tool of said material processing system;

recording second tool data for at least one observation during said second process in

said process tool to form a second tool data matrix, said second tool data vector comprises

said plurality of tool data parameters;

performing a matrix multiplication of said second tool data matrix and said correlation

matrix to form predicted process performance data;

comparing said predicted process performance data with target process performance

data; and

determining a fault condition of said material processing system from said comparing

step.

28. The method for detecting a fault in a material processing system as recited in

claim 27, wherein said first process performance data and said predicted process performance

data comprises at least one of mean etch depth and etch depth range.

29. The method for detecting a fault in a material processing system as recited in claim 27, wherein said first tool data and said second tool data comprises at least one of a capacitor position, a forward RF power, a reflected RF power, a voltage, a current, a phase, an impedance, a RF peak-to-peak voltage, a RF self-induced DC bias, a chamber pressure, a gas flow rate, a temperature, a backside gas pressure, a backside gas flow rate, an electrostatic clamp voltage, an electrostatic clamp current, a focus ring thickness, RF hours, and focus ring RF hours.

30. The method for detecting a fault in a material processing system as recited in claim 27, wherein said step of performing a partial least squares analysis includes the step of determining a minimum number of partial least squares components that substantially explains a correlation between said first tool data and said first process performance data.

31. The method for detecting a fault in a material processing system as recited in claim 27, wherein said step of performing a partial least squares analysis includes the steps of:

calculating variable importance in projection data defined as an influence on said first process performance data matrix of said first tool data matrix; and

refining said first tool data matrix based upon an analysis of the variable importance in projection data.

32. The method for detecting a fault in a material processing system as recited in claim 27, wherein said step of performing a partial least squares analysis includes the step of verifying the fitting power of said process performance prediction model by inspecting at

least one of a fraction of a sum of squares of all of said first tool data and said first process

performance data explained by a partial least squares component, a fraction of a variance of

all of said first tool data and said first process performance data explained by a partial least

squares component, a cumulative sum of squares of all of said first tool data and said first

process performance data explained by a partial least squares component, and a cumulative

variance of all of said first tool data and said first process performance data explained by a

partial least squares component.

33. The method for detecting a fault in a material processing system as recited in

claim 27, wherein said step of performing a partial least squares analysis includes the step of

verifying the predictive power of said process performance prediction model by performing

cross validation.

34. The method for detecting a fault in a material processing system as recited in

claim 26, wherein said step of comparing said predicted process performance data with a

target process performance data comprises determining difference data between said

predicted process performance data and said target process performance data.

35. The method for detecting a fault in a material processing system as recited in

claim 34, wherein said step of determining a fault condition of said material processing

system comprises comparing said difference data with threshold difference data.

36. The method for detecting a fault in a material processing system as recited in

claim 35, wherein a fault in said material processing system is detected when said difference

data exceeds said threshold difference data.